Development of Primary Volatile production in COMET C/2009 P1 (GARRADD) During its 2011-2012 Apparition.

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We quantified primary volatiles in comet C/2009 P1 (Garradd) through pre- and post-perihelion observations acquired during its apparition in 2011-12 [1, 2, 3]. Detected volatiles include H_2O, CO, CH_4, C_2H_2, C_2H_6, HCN, NH_3, H_2CO, and CH_3OH. We present production rates and chemical abundance ratios (relative to water) for all species, and 1-D spatial profiles for multiple primary volatiles. We discuss these findings in the context of an emerging taxonomy based on primary volatiles in comets [4].

We used three spectrometer/telescope combinations. On UT 2011 August 7 (R_h 2.4 AU) and September 17–21 (R_h 2.0 AU), we used CRIRES at ESO's Very Large Telescope (VLT) [1]. On September 8 and 9 (R_h 2.1 AU), we used NIRSPEC at Keck-2 and CSHELL at IRTF [2]. Using NIRSPEC on October 13 and 2012 January 08 (R_h 1.83 and 1.57 AU, respectively), we detected nine primary volatiles pre-perihelion, and six post-perihelion [3].

CO was enriched in Garradd while C_2H_2 was strongly depleted. C_2H_6 and CH_3OH displayed abundances close to those measured for the majority of Oort cloud comets observed to date. The high fractional abundance of CO identifies comet C/2009 P1 as a CO-rich comet. Spatial profiles revealed notable differences among individual primary species.

Given the relatively large heliocentric distance of C/2009 P1, we explored the effect of water not being fully sublimated within our field of view and we identify the "missing" water fraction needed to reconcile the retrieved abundance ratios with the mean values found for "organics-normal" comets.

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[1] Paganini et al. 2012, *ApJ Lett.* 748, L13. [2] Villanueva et al. 2012, *Icarus* 220:291. [3] DiSanti et al. 2012, in prep. [4] Mumma & Charnley 2011, *ARAA* 49:471.